A.I. Memo # 460

LOGO Memo # 48

Assessment and Documentation of A Children's Computer Laboratory

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Abstract

This research will thoroughly document the experiences of a small number of 5th grade children in an elementary school computer laboratory, using LOGO, an advanced computer language designed for children. Four groups of four children will be taught a 10-week LOGO course. Detailed anecdotal records will be kept, and observers will note the development of the children's computer programming skills, and the acquisition of knowledge in the areas of mathematics, science, and language, and of cognitive strategies and attitudinal changes which transfer beyond the specific subject matter studied.

A collaborative team, including MIT research scientists, a public school teacher and curriculum developer, and consultants in science curriculum evaluation from Education Development Center, will conduct the research. A final report will be prepared by the project staff, summarizing the experiences of each about the success of the LOGO classroom experience in helping children acquire skills and knowledge in the target areas. The success of the assessment methodology will be discussed and strategies suggested for a large scale evaluation to be conducted in the future.

PROPOSAL SUMMARY

This proposal attempts to take a further step in making the work of the M.I.T. LOGO Group, and other researchers in LOGO, available for implementation in realistic school settings. The proposed documentation of a LOGO learning experience will offer specific information about the use of presently advanced educational technology in an elementary school classroom. It will pinpoint the skills and knowledge acquired by the students, and provide evidence about the possible transfer of learning into more general cognitive skills such as problem-solving. The information and the methodologies tested will point out possibilities for large scale verification of the observed gains, as well as provide the basis for practical curriculum development. The information provided will also help form a basis for the decisions to be made by educators throughout the country in the next few years concerning the use of computational technology in public school classrooms.

The research plan calls for the installation of a small computer laboratory in the Lincoln School, an elementary school in Brookline, Massachusetts. The laboratory will consist of four self-standing computer systems, each using a DEC LSI-11 processor, and including graphics, music and hard copy capabilities. (The LOGO system prepared for it can be run on any PDP-11 computer currently in use in schools.)

The main study will focus on a detailed documentation of four groups of

four children each, with each group spending 4-5 hours per week for ten weeks in the computer laboratory, receiving instruction in LOGO programming. In addition there will be other classes and informal "computer club" activities, but the observation of these activities will be less intensive and less systematic.

The children will be instructed in the basics of the LOGO language, and the bulk of their time will be spent on individually chosen projects in which the children have the opportunity to apply their programming skills in the areas of geometry, computer graphics designs, computer animation, music, games and quiz programs, etc.. In addition to individually chosen projects, the children will also be exposed to specific "mini-units" in several of the above areas.

The main thurst of the research will be to thoroughly document the selected 16 childrens' learning as they participate in the LOGO experience. The means for documenting the learning will be as follows: anecdotal records of the work of each child kept by the teacher and observer each day; charts showing the progress of each child in certain pre-defined skills in the areas of computer programming, mathematics, and language arts; specially designed assessment activities will be used to observe the childrens' progress in cognitive areas such as problem-solving; interviews will be devised to measure the childrens' improvement in attitudes toward themselves as learners and towards the use of computers.*

Although a statistical analysis will not be attempted, a final report will be published summarizing the findings, and providing a brief description of the overall work of each child. The research team will be a collaborative group including:

NARRATIVE:

1. NEED FOR THE STUDY

(a) Background of the M.I.T. LOGO Group The cost of computer power is divided by ten every five or six years. This means that you will bring ten times as much computer power for a given investment in 1980 as you could have bought for ten times that investment in 1968. The LOGO project has been dedicated since its very small beginnings in 1968 to developing the technological infrastructure and the conceptual framework for the kinds of educational uses of the computer which we expected (and still expect) to become widely used in the nineteen eighties. Researchers who are not familiar with this work can obtain some insight into it by reading the appended paper "Uses of Technology to Enhance Education". The LOGO tradition diverged from other trends in the development of computer uses for education through our belief that people will do very different things with inexpensive powerful computers than they were doing with the more expensive less powerful computers. Indeed the new uses will not even be continuous with the old. They will use different computer languages, engage different subject matters, etc.. Such a perspective led to a strategy of research in a somewhat rarefied laboratory atmosphere where we had little interaction with people who were already working with computers in schools. In our isolation we developed methods and machines which seemed at the time outrageously cost-ineffective.

Two salient trends are now changing the relation of cost-effectiveness.

The first is the growing crisis in the schools involving loss of effectiveness in relation both to the learning of basic skills and to the development of social trust and confidence. The second is technology which shows itself already as the falling cost of computer power and will in the future take the form of an inexorable movement towards mass diffusion of personal computers on a scale which may catch up with that of television sets within a decade. Those two trends transform the products of our work from the status of "ivory tower toys" to that of usable instruments whose cost-effectiveness is already acceptable and will increase rapidly in the next few years. It is obviously time for us to emerge from our sheltered environment. <u>Concretely this means that we have to demonstrate to a generally sceptical world that our computer based learning environment can be operated in an ordinary school setting by teachers who are not computer scientists and that the students gain something valuable and unique from this experience</u>.

Our attempts to do this have produced some "growing pains". The worst of these was felt in a rejection by the N.S.F. of a recent proposal. When we wrote the paper "Uses of Technology to Enhance Education" and presented it to the N.S.F. in 1973 as a proposal to develop technologies, theoretical ideas and computer systems, we could write with ease, confidence and mastery about an area of work in which we had long experience. This accounted for the success of the proposal which was reflected not only by the award of a grant of $1,100,000 but, even more encouragingly, by the thousands of requests we have received for copies of the document.

Although not published in a "journal" it has become quite influential internationally. In 1976 we presented a new proposal to operate an experimental class in which the technologies, ideas and systems developed earlier could be tested. This proposal had a more mixed reception. The reviewers agreed (almost unanimously) that our work was innovative and important and that we were far ahead of anyone else in developing the uses of computers in elementary education. However they noted with concern a number of weaknesses. For example, we had little experience in working with schools; we seemed to have paid insufficient attention to teacher training; our concept of "teaching materials" was very different from what a teacher in a school would expect; the organization of our laboratory had a looseness which was appropriate for pure research but not well adapted to an operational project such as running a school or preparing materials for general dissemination; we are vague about evaluation; etc.. In short, while the reviewers liked the project, they expressed doubts about whether we had demonstrated ability to carry it through.

In the present proposal many of these weaknesses are remedied. This proposal is more modest both in scale and in ambition, but its goals are correspondingly more clearly defined and more clearly related to the more practical problem of building credibility amongst school educators.

The charges are not merely on the level of words and plans. The new proposal embodies the results of a critical further six months of life of our project during which time attention has been focussed on developing an approach to teacher training and to the methodology of description and

reporting of what actually happens when children work in our computer based learning environments. During this period we also laid the foundations for working relationships with two school systems (the Brookline Schools in which we propose to do the work described below and the Yorktown Heights B.O.C.E.S. where a LOGO project for emotionally disturbed children is now being operated by a teacher trained by us at M.I.T.) We have also begun to explore the possibility of a partnership with an external organization (E.D.C.) experienced in developing educational materials (see appended letters of intent of cooperation from Brookline Schools and E.D.C.). Finally, under the heading of listing changes in our group we mention that the form of this new proposal, the way our research interests have developed and the emergence of these relationships owe a great deal to two relatively new members of our group. These are Bob Lawler and Dan Watt. Both members are dedicated to the problems of improving teaching and of understanding and describing what actually happens in teaching and in learning. Both are mature persons who joined us at M.I.T. after a long period of professional involvement in the "real world" (of computers and of schools respectively.)

(B) What A Kid Learns When He Learns LOGO.

We use the word LOGO here to refer not only to a particular programming language but to a general approach to education which has grown around it. One of the principles of this approach is that we never teach "programming" as such; it is always learned (as is a child's first natural language) as an integral part of other activities which are perceived by the student as worthwhile in themselves. In the case of the work we propose here, this

activity is initially in the area of computer graphics. We have found through informal experiments that some or other form of this activity proves attractive to the vast majority of children (and adults) including those whose previous record of scholastic non-performance would suggest that no such intellectualized activity would "grab" them. So the children conceptualize their initial activities as drawing with the computer, teaching the computer to draw, etc.. But this activity happens (by design!) to be extremely rich in various kinds of knowledge including: knowledge about programming, geometric knowledge, arithmetic knowledge, general "problem-solving" or "heuristic" knowledge and above all a sense of the power of relating to one's own intellectual (including intuitive) activities. Our hope is that the child is acquiring knowledge in all these areas as he goes about learning to drive program-controlled turtles over the computer display.

The research problem underlying this proposal is how to document the child's life in the LOGO experience in such a way as to be able to discuss sensibly whether any such thing is happening. To formulate this task a little better we first give some examples of phenomena we have encountered in informal work with children. The research goals will focus on selecting a number of such phenomenon which seem particularly informative, frequently observed and easy to see.

PHENOMENON #1: Turtle-LOGO has neither a Threshold nor a Ceiling.

It is well known that programming a computer can be a "turn-on" for many

children. But in the usual BASIC computer environment the threshold of knowledge needed to experience the thrill of programming is too high to draw in those children who come with a resistance to school learning especially mathematical learning. Our experience with LOGO indicates that this threshold effect is not at all related to aptitudes or intelligence or even to "task". For LOGO is designed so that there is no effective threshold, by which we mean that anyone can learn in the first minute of contact with the machine enough to do something interesting, and can progress from there in equally small increments of learning if he so wishes to a degree of sophistication ("no ceiling") which scarcely anyone obtains in a BASIC environment.

PHENOMENON "2: A Mini-World Where the Concept of "Attention Span" is not Applicable.

We have seen children referred to us by counsellors as "having an attention span of less than five minutes" work for an hour or two without a break at LOGO. One should not be surprized that some activities do this: dancing clearly does and movies etc.. What is out of the ordinary is that this is a very "mathematical" activity.

PHENOMENON #3: Curing Mathophobia

There are children who did not learn arithmetic because they hated numbers until they had their first truly joyful consciously mathematical experience. Once they stop hating the numbers they begin to enjoy them and learn to manipulate them.

PHENOMENON #4: Learning Line Integrals Without Noticing It -- Also Differential Equations.

The first three phenomena might have seemed biased to children in difficulty. This one applies to children of all ages. For a turtle drawing a curve is going forward a little, turning a little and so on.

It is easy for the program to accumulate a running sum of some quantity as it goes along. A little thought shows that this is a line integral and a very powerful idea which more than one child has re-invented. (For a case study see "Uses of Technology to Enhance Education", p. 57-63, especially p 60). This phenomenon illustrates many aspects of mathematics in a computational context. Notice how the concept of line integral comes to be more elementary and (of course) more general than what is normally regarded as the "natural first concept" of integral line as tied (artificially) to the special case of areas under a curve.

We have evidence that this reversal of order avoids the confusions encountered by almost everyone who follows the traditional sequence. (Even many very mathematically sophisticated students find it hard not to look for the area when they first encounter a line integral.) Whether this kind of consideration is relevant to what children should do in their mathematical work is, of course, open to controversy. But readers who think that it is should note that the Turtle definition of a circle ("Uses of Technology..." p 47) takes as fundamental the fact that it is a curve of constant curvature and one could argue that this "differential" or "local" definition really is seen by modern science as more fundamental

than either the Euclidean or the Cartesian way of defining the circle by the property of equal radii.

PHENOMENON #5: The Thrill of Making Complex, Hierarchical Construction

Euclid had this thrill. Most people have to experience it vicariously. But in a LOGO programming context children are constantly using sub-procedures to build super-procedures. Some fall in love with the idea of making something very complex by building a little at a time. Perhaps this will give them a taste for one of the most important aspects of all intellectual activity, particularly mathematics.

PHENOMENON #6: Computer Procedures and People Procedures, (or "the Computer Metaphor").

It is easy to anthropomorphize turtles. So one way to make a procedure for a turtle to do something (eg. draw a circle or the complex example on pp 57-63 of "Uses of...") is to do it yourself, observe your own behavior and express that in "turtle language". So: walk in a circle! see that this can be described as go forward a little and turn a little and keep doing the same thing! Finally see that this is the good differential equation for a circle as object with constant curvature!

Conversely, we have taught children to learn a new skill eg. juggling by thinking of themselves (for this purpose) as computers and writing sub-procedures. It really seems to help most people. A research question bears on the extent to which children will do this spontaneously in new

areas of learning.

(C) <u>A Need for More Systematic Study and Documentation of LOGO Learning.</u> Under (B) we gave a small sample of phenomena which have been reported at some time by members of our laboratory who have worked with children. Neither the conditions of work nor the expertise of the workers favored the collection of systematic, credible data about such phenomena. Our first goal in the work we want to do next is to gather such data by having small classes taught systematically by a disciplined, observant teacher while observers collect as much data as possible. The observers will definitely include the following:

Our next goal is derivative from this one. The truth is that neither we nor anyone knows how to collect and report such data in an "optimal fashion". We have already found it valuable to use more than one method of data collection and analysis for comparison. In these more systematic studies we shall continue to do so and treat the comparative problem as a research goal in itself. Although such work must, almost by definition, be open-ended we cite one example of the kinds of issues that will arise and perhaps be clarified.

(D) <u>Contrasting Two Observation Methodologies</u>

We include as appendix I a paper by R. Lawler who is presently a graduate student in our laboratory. One of Lawler's specialties is the analysis of

very fine-grained protocols taken from a subject working on a problem. In the paper he makes an interpretation of the dynamics of formation of objectives by a child. In his theoretical work he contrasts two modes of work which he calls "Planning" and "Bricolage" (follwing Levi-Strauss). The planning model represents the subject in terms of a fixed "top goal" for which sub-goals are generated recursively. In the bricolage model the "objectives" evolve in the course of the work, opportunistically, by association, as manifestations of latent, pre-conscious desires etc.. It is clear that most people adhere to each of these models on some occasion.

Some people <u>value</u> one more than the other. Some people carry this to an extreme of rigidity which impedes effective work. We have observed that such rigidity often shows itself in areas of work in which the subject is not at ease such as mathematics and as the rigidity softens at least some "mathematical blocks" go away. So this suggests that it would be interesting to do such analysis in a mode of tracking the dynamics between "planning" and "bricolage" as a student goes through a LOGO learning experience. On the other hand the collection of the data might prove impossibly difficult in a class situation. This is a kind of question we shall try to illuminate. Another side of the question can be raised by asking whether some phenomena can be detected by a less intimate form of data collection, such as the appended sample of notes taken from Dan Watt's records of a child, Sam, learning LOGO at M.I.T. (see Appendix E.)

(E) <u>Our Central Plan for Next Year</u>

Specifically, we wish to operate four LOGO based classes at fifth grade

level. The classes will be artificial in that they will be small; there will be only four students in each class. But in several other respects the classes will be very much more realistic than any we have operated in the past. They will be run in an actual public school and by an experienced fifth grade teacher who will by being there have had exactly one year of training and experience in the use of computers. Our primary goal is to document what takes place in the class: what materials are used; what transactions take place between students, teacher and computers; what the students learn both in the narrow sense of acquiring the skills and concepts we explicitly teach and in the wider sense of how this affects school-work, problem-solving, attitudes, etc.. The products of the work relevant to this goal will be a coherent document which will be published to give the education community the most detailed possible concrete image of what can happen in a computer based learning environment.

A secondary goal will be the discussion and (as far as possible) the appraisal of different methods of data collection, observations, measurements etc.. The small sample will make it possible to collect a great deal of information about each child. It will, of course, also prevent statistically reliable conclusions to be drawn. But we are firmly convinced that this trade-off is a correct research strategy. The experiment must not be described as an "evaluation of the effects of learning LOGO". Rather it is a necessary preliminary step towards such an evaluation. We shall learn from it that certain observations and measures can be made and seem intuitively meaningful in the situation while others

are too difficult, obviously unrelated, etc.. If the first class has many members we (or some other research group) will be in a good position to plan an evaluation study on a more significant scale. However it should not be forgotten that certain conclusions of an evaluative nature will be just as valid with 8 subjects as with 100. For example, if all 16 children were to achieve the level of programming competence we describe in the appended breakdown of the teaching plan, we certainly could conclude that most kids from the socio-culturo-economic background of our school will be able to learn LOGO with a teacher like Dan Watt. More subjects from the same background, taught by the same team would not make the conclusion firmer.

(F) Related Work

Two kinds of work are relevant to the assessment of the value of this project:

(1) Work related to making LOGO more widely available The N.S.F. has awarded a grant to Bolt, Beranek & Newman of Cambridge Mass. to facilitate dissemination of LOGO. In addition to this systematic project many firms and computer science centers are engaged in new or improved implementations of LOGO.

(2) Experimental Work Similar to Our Research Plan We believe that this is the only project which sets out to study LOGO learning systematically in a regular elementary school. Other projects in the same spirit are: the work at the University of Edinburgh with high school students; the work at the

Yorktown Heights B.O.C.E.S. on elementary school children with severe emotional problems; work of the LOGO center at the University of Quebec in Montreal on individual children on a clinical basis (i.e. each child is given a different experience depending on his special needs and interests); and work at the XEROX research center at Palo Alto (which does not use LOGO itself but the related language SMALLTALK) where work with individual children is conducted in a laboratory rather than a school setting.

We are in touch with all these groups and make systematic use of their ideas in designing our teaching material and our observational procedures.

2. PROJECT GOALS.

A. the project is designed to answer the following questions:

1. How much can 5th grade children, in a regular school setting, learn about computer programming, using a LOGO environment. (See Computer Programming Skills and Concepts in the LOGO course, Appendix A.)

2. What concomitant skills that are part of the standard school curriculum (mathematics, science, and language) do children learn in the course of their LOGO work? Do they acquire concepts that would normally be considered "advanced" for their age level? (See Appendix B.)

3. What non-standard skills (problem-solving through planning and debugging; use of procedural thinking and computer metaphors, etc.) do children in the course of the LOGO work?

4. Does the LOGO experience produce any changes in the child's attitude towards learning or toward himself/herself as a learner, both in general, and in relation to particular subjects (e.g. mathematics)?

5. What changes, if any, can be found in the child's attitude towards using computers and towards the role of computers as part of our technological society?

B. Comments on the usefulness of answering these questions:

1. Provide specific information about the use of the LOGO computer language, hardware system and philosophy of instruction, in a realistic public school setting. Much of this knowledge is resident in the experienced staff members of the LOGO group. The reporting function of this experiment will bring it into publicly accessible form.

2. Provide evidence to educators in school systems and universities and funding agencies to justify the use of LOGO as an elementary school activity -- forming a bridge to the technological environment of the near future.

3. Clarify the needs for future work in curriculum development and teacher training to implement LOGO successfully in realistic school settings during the next few years.

4. Clarify the indirect learning potential of LOGO in both conventional and non-conventional areas of school curriculum and point the way to large scale verification of this potential in future experiments.

3. RESEARCH PLAN

A. Design.

1. We will set up a computer laboratory in the Lincoln School, Brookline, Mass. consisting of 4 stand alone computers with associated equipment (see appendix C for description of the laboratory.)

2. We will teach 4 ten-week classes, with 4, 5th grade students in each class. Each class will meet 4-5 hours/week for a total of 40-50 hours of exposure time for each child. (See appendix D for a description of the course material and eaching methods.)

3. Two of the classes will be taught in the fall, two in the Spring, with time allotted before, between, and after the classes for planning and documentation.

4. The classes will be taught by an experienced classroom teacher, trained in LOGO, and observed by MIT graduate students. Detailed anecdotal records will be kept by the teacher and observer, as well as charts documenting each child's acquisition of computer programming skills and traditional school subject matter. (See appendix E for description of the approach to observational record keeping.)

5. Evaluators experienced in informal education, and cognitive psychology, from Education Development Center (Newton, Mass) will participate in the

design of activities for children, to be used informally in the LOGO classroom, to assess the children's acquisition of understandings in problem solving, use of procedural thinking and computer metaphors, and will interpret the children's responses to these activities. (See appendix F for examples of such activities).

6. Consultants in the area of affective behavior will devise and conduct interviews to assess each child's attitude toward's learning, towards school, and towards himself as a learner, as well as to assess each child's attitude's towards computers. These interviews will be conducted once before, once during and once after each set of classes.

B. Samples

1. The student population will consist of approximately 16 fifth grade students at the Lincoln Elementary School, Brookline, Mass.. Lincoln School is in a lower socio-economic area of Brookline, a suburb, adjacent to Boston. (The children will represent a reasonably normal distribution of prior academic achievement, stressing those of average ability. Since the scope of the experiment is small and the number of subjects statistically insignificant, there will be no attempt to select a control group for this experiment.

2. This experiment will be a continuation of a cooperative relationship between the Brookline Public Schools, and the LOGO Group.

During the 1976-77 academic year, Dr. Daniel H. Watt, a fifth grade teacher at the Lincoln School, has been spending a year of sabbatical leave as a visiting research associate with the LOGO Group. Dr. Watt will be the teacher of the LOGO classes in the proposed experiment. Dr. Robert I. Sperber, Superintendent of Schools, Dr. Jacqueline P. Clement, Assistant Superintendent for Curriculum and Instruction, and the Testing, Research and Evaluation Committee (a group of Brookline teachers and administrators which must approve any educational research performed in the Brookline Schools) have formally endorsed a LOGO experiment within the Brookline Schools. The plan has also been approved by Mr. Gerard P. Cote, Principal of the Lincoln School, and discussions about the details of implementation have begun with teachers at the Lincoln School (see attached letters).

3. Consultants from Education Development Center, Inc., a private, non-profit organization with wide experience in the development, implementation, and evaluation of Science and Math curricula have agreed to participate in the preparation, use and documentation of informal means of assessment (see attached letters).

C. Data Analysis And Interpretation:

This plan does not lend itself to statistical approaches to the analysis of data. Rather, we propose to write a final report, in a form suitable for widespread publication. This report will include:

1. A summary of what the children learned in the area of computer programming, and traditional school subjects, as taken from the anecdotal records and the charts kept by the teacher and observer.

2. An analysis of the results of the informal assessments of the children's development in problem solving tasks and in the use of procedural thinking.

3. An analysis of the results of interviews conducted to assess the affective effects of the experience on the children.

4. A brief summary, of each child's progress, taken from the anecdotal records.

5. Discussion of new questions raised by the experiment, and suggestions for further research to provide more formal validation of the results, and for development in the areas of teacher training and curriculum materials.

We feel that the results of our work documented in this way, will demonstrate for the first time the effectiveness of the LOGO learning environment within a public elementary school. Other researchers will have some specific information on which to base further experiments. School and University Educators will have information on which to begin to consider the practical implementation of LOGO in a more realistic way. Success of the experiment will suggest a strong effort in the areas of teacher training and curriculum development, based on the experiences described in

our report.

5. SCHEDULE OF ACTIVITIES:

A. Preparatory Phase: Sept. - Oct. (6 weeks)

During this period we will be installing equipment, preparing specific teaching plans, and devising, with the participation of consultants, charts and anecdotal record keeping systems, assessment activities for the children to carry out during the classes, and interviews for use in the affective areas. We will also provide a two day training program for the teachers at Lincoln School, prior to the beginning of the school year. We will consult with the teachers about the selection of students, and in late September, conduct any preliminary interviews or assessments with the 8 students selected.

B. First Class Session: Oct. - Dec. 1977 (10 weeks)

During this period we will be holding daily classes with the students. Assessment activities will be built into the classes at regular intervals and observed or conducted by the consultants. The children will be interviewed at approximately the midpoint of the 10 week period, and again at the end of the period. Anecdotal records, and progress charts will be kept for each child.

C. First Assessment and Revision: Jan. - Feb. (6 weeks)

We will collect and organize the information from the anecdotal records and charts. Also, make a preliminary assessment of the effectiveness of the

assessment activities and interviews, and make revisions if necessary. Consult with the teachers about the children's reactions to the LOGO classes, and select and interview the children for the next phase.

D. Second Class Session: Feb. - April 1978 (10 weeks)

During this phase we will repeat the activities of the first class session, with revised lesson plans, and teaching materials, assessment activities and interviews.

E. Analysis of data; Writing of Final Report: May - Aug. 1978 (12 weeks)

We will carefully organize the data from the charts for all the children in both groups; write up the summaries of each child's work; analyze the results of the assessment activities and interviews and write the final report.

5. PERSONNEL QUALIFICATIONS:

A. Professor Seymour Papert has a background of teaching and research in mathematics and in the theory of intelligence. The latter interest led him to spend five years in close collaboration with Piaget at the University of Geneva and to become one of the core of participants in the symposia of Piaget's Centre d'Epistemologie Genetique. Since 1964 he has been at M.I.T. where he is Professor of Mathematics as well as holding the Cecil and Ida Green Chair in Education. From 1969 to 1974 he was co-director with Minsky of the Artificial Intelligence Laboratory. He initiated the

idea of LOGO and has collaborated on LOGO development with many workers at M.I.T., at Bolt, Beranek and Newman, and at other centers of education research. He sees the concept of Turtle Geometry as an expression of the unification of three intellectual roots: mathematics, Piaget's epistemology and computer science. (See appendix for vitae)

B. Dr. Daniel H. Watt, presently on sabbatical leave from the Brookline Public Schools, Brookline, Mass., is spending the 1976-77 academic year as a Visiting Research Associate with The LOGO Group. He has been a teacher of fourth and fifth grades at the Lincoln Elementary School in Brookline for the previous seven years. Prior to joining the Brookline Faculty, Dr. Watt was a staff developer with Elementary Science Study, part of Education Development Center, Inc., an elementary school curriculum development project, sponsored by the National Science Foundation.

By combining expertise in Computer Science, and Psychology, and Elementary science and elementary school teaching, this team will be uniquely able to carry out the proposed study. Furthermore, Dr. Watt will be working with the Brookline School system, paid by this grant under a sub-contract (see budget worksheet) to the school system. In this way, he will be able to maintain effective liason with the parents and Brookline school administrators.

C. Other MIT faculty, EDC consultants, DSRE consultants.

6. ORGANIZATION AND MANAGEMENT PLAN The research team, consisting of Professor Papert, Dr. Watt, faculty members of the MIT LOGO Group, MIT graduate students and consultants from Education DEvelopment Center, and from the Divison for Study and Research in Education of MIT, will function under the supervision of Professor Papert. As Principal Investigator, he will have responsibility for oversight of the entire project. With Dr. Watt, he will coordinate the work of the outside consultants, and write the interim progress reports. Dr. Watt and Professor Papert will also share responsibility for writing the final report describing the LOGO learning experience and summarizing the findings of the teachers and the observers.

Dr. Watt will have responsibility for teaching the LOGO classes, maintaining liason with the Brookline Public Schools, supervising the graduate student observers, and, with the observers, writing the anecdotal notes on each class and keeping the "progress charts" on each child. He will have responsibility for coordinating the classroom work of the consultants. He will also have responsibility for these portions of the final project report which summarize the work of each child, and which analyze the information obtained from the progress charts.